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The dielectric ARC layer can be annealed at a temperature of at least 400°C, or in a temperature range between about 400°C and about 1,000°C. The annealing process can be conducted in a gas environment that contains at least one of N_2 and O_2.

REMARKS

Thorough examination and careful review of the application by the Examiner is noted and appreciated.

Claims 1-17 are pending in the application. Claims 1-17 stand rejected.

Objection To The Claims

Claim 11 has been objected to as being substantially a duplicate of claim 10.

A typographical error in claim 11 has been corrected to alleviate the Examiner's objections.

Claim 12 has been objected to as containing the term "reflective" index. Claim 12 has been amended to change the term to "refractive" index.

Claim 14 is objected to for containing a typographical error. Claim 14 has been corrected to alleviate the Examiner's objections.

Claim 17 is objected to. Claim 17 has been amended to alleviate the Examiner's objections.

Claim Rejections Under 35 USC §102

Claims 1-2, 5, 8-11 and 13-16 are rejected under 35 USC §102(e) as being anticipated by Plat et al '751. It is contended that Plat et al teaches the present invention as defined in independent claims 1 and 13.

The rejection of claims 1-2, 5, 8-11 and 13-16 under 35 USC §102(e) based on Plat et al is respectfully traversed.

Independent claims 1 and 13 have been amended to further recite "annealing said dielectric ARC layer ... at a temperature of at least 500°C" (claim 1), and "heating said semiconductor substrate to a temperature between about 500°C and about 1,000°C" (claim 13).

The Applicants respectfully submit that such annealing temperature range is clearly not taught or disclosed by Plat et al, i.e. at 427°C to 482°C.

The Applicants further submit that, regarding claim 2, Plat et al does not teach the deposition of SiONH recited by claim 2 at col. 5, lines 45-54. Regarding claim 8, Plat et al clearly does not teach that ARC layer can be formed of SiO_2 or SiONH at col. 5, lines 53-54. Regarding claim 9, Plat et al clearly does not teach an annealing temperature range between 500°C and 1000°C, as previously argued. Regarding claim 14, the Applicants respectfully submit that Plat et al clearly does not teach annealing the ARC layer in order to vary the extinction coefficient by at least 10%.

The rejection of claims 1-2, 5, 8-11 and 13-16 under 35 USC §102(e) based on Plat et al is respectfully traversed. A reconsideration for allowance of these claims is respectfully requested of the Examiner.

Claim Rejections Under 35 USC §103

Claims 3-4 are rejected under 35 USC §103(a) as being unpatentable over Plat et al in view of Chang et al '146. It is contended that while Plat et al does not teach a method wherein SiON ARC layer is deposited by a PECVD technique, such is taught by Chang et al.

Claims 3-4 depend on independent claim 1 which further recites the deposition on a SiNx layer and furthermore, the annealing of the SiON at a temperature of at least 500°C in an environment of N_2. The Applicants respectfully submit that such are not taught or disclosed by Chang et al.

The Applicants therefore respectfully submit that claims 3-4 are not rendered obvious under 35 USC §103(a) based on Plat et al and Chang. A reconsideration for allowance of these claims is respectfully requested of the Examiner.

While the Examiner conceded that Holscher et al does not explicitly teach the ARC layer is deposited on either a SiN or a polysilicon layer, it is the intention of Holscher to provide an effective ARC layer that can be used on top of a reflective layer and beneath a photoresist layer to suppressive reflected radiation

waves from the reflective layer. Moreover, the Examiner contended that Plat et al teaches that SiON ARC layer is deposited on top of a polysilicon layer.

The present invention as narrowly recited in independent claims 1 and 13, recites the process step of "depositing a dielectric ARC layer on said SiN_x or said polysilicon layer". The criticality of such process step is only taught by the present invention. As stated in the specification at page 3, line 8 through page 4, line 1:

> "The surface of a polysilicon layer or a silicon nitride layer is also highly reflective, almost matching that of an aluminum layer. The high reflectivity of the surface of polysilicon or silicon nitride renders an imaging process for lithography difficult to carry out. The use of an anti-reflective coating layer on top of the polysilicon or the silicon nitride prior to depositing a photoresist layer is therefore necessary. **For compatibility reasons, a dielectric type anti-reflective coating material is more suitable for coating the polysilicon or the silicon**

nitride surface. The dielectric ARC, which is quite different than organic ARC such as organic dyes **or inorganic ARC** such as TiN or TiW, may be SiO_2, SiON or SiONH. The dielectric ARC is deposited as a bottom ARC, i.e. directly on a wafer under a photoresist layer by a plasma CVD method."

The Applicants respectfully submit that neither Holscher nor Plat recognizes such criticality and such use of a dielectric ARC layer, specifically, on a surface of SiNx or polysilicon. Moreover, neither reference teaches the coating of a dielectric ARC layer on SiNx.

The rejection of claims 1-2, 6, 8-11 and 13-16 under 35 USC §103(a) based on Holscher et al and Plat et al is respectfully traversed. A reconsideration for allowance of these claims is respectfully requested of the Examiner.

Claims 3-4 are rejected under 35 USC §103(a) as being unpatentable over Holscher et al '292 in view of Plat et al and further in view of Chang et al '146. It is contended that while the combination of Holscher and Plat does not teach the SiON layer is deposited by PECVD, such is taught by Chang et al.

Claims 3-4 depend on independent claim 1, which the Applicants have shown is not rendered obvious based on Holscher and Plat while neither reference recognizes the criticality of using a dielectric ARC layer on top of SiNx or polysilicon. Moreover, neither Holscher nor Plat et al teaches the forming of a dielectric ARC layer on top of SiNx. The Applicants respectfully submit that the additional reference of Chang et al does not lend any weight in a §103 rejection of claims 3-4.

The rejection of claims 3-4 under 35 USC §103(a) based on Holscher et al, Plat et al and Chang et al is respectfully traversed. A reconsideration for allowance of these claims is respectfully requested of the Examiner.

Claims 5, 7 and 17 are rejected under 35 USC §103(a) as being unpatentable over Holscher, in view of Plat and further in view of Sandhu et al '282. It is contended that while the combination of Holscher and Plat does not teach a method wherein the gas environment used in annealing is O_2, such is taught by Sandhu.

Claims 5 and 7 depend on independent claim 1, while claim 17 depends on independent claim 13. As presented above, the Applicants have clearly shown that independent claims 1 and 13 are not rendered obvious based on Holscher and Plat. The Applicants therefore respectfully submit that the additional reference of Sandhu does not render the present invention claims 5, 7 and 17 obvious. A reconsideration for allowance of these claims is respectfully requested of the Examiner.

Claim 12 is rejected under 35 USC §103(a) as being unpatentable over Holscher, Plat, further in view of either Lee '672 or Yao '734. It is contended that Lee teaches the range of refractive index and a range of the extinction coefficient. Such range of values is also taught by Yao.

The rejection of claim 12 under 35 USC §103(a) based on Holscher, Plat, Lee and Yao is respectfully traversed.

Claim 12 depends on independent claim 1, which the Applicants have clearly shown is not rendered obvious based on Holscher and Plat since neither reference recognizes the criticality of forming a dielectric ARC layer on SiNx or

polysilicon. Moreover, neither of the two primary references recognizes the deposition of a dielectric ARC layer on SiNx. The Applicants therefore respectfully submit that the additional references of Lee and Yao do not lend any additional weight based on the two primary references. A reconsideration for allowance of claim 12 is respectfully requested of the Examiner.

Based on the foregoing, the Applicants respectfully submit that all of the pending claims, i.e. claims 1-17, are now in condition for allowance. Such favorable action by the Examiner at an early date is respectfully solicited.

Attached hereto is a marked-up version of the changes made to the specification, claims and abstract by the current amendment. The attached page is captioned "Version With Markings To Show Changes Made".

In the event that the present invention is not in a condition for allowance for any other reasons, the Examiner is respectfully invited to call the Applicants' representative at his

Bloomfield Hills, Michigan office at (248) 540-4040 such that necessary action may be taken to place the application in a condition for allowance.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In The Specification

Paragraph beginning at line 4 of page 4 has been amended as follows:

> Two important optical properties for a dielectric ARC layer are the [reflective] refractive index, n; and the extinction coefficient, k. The values of n and k are dependent upon the thickness of the coating layer deposited. The reflective index n is a ratio of c/v, where c is the light velocity in vacuum, and v is the light velocity in the material of interest. The extinction coefficient k is also a function of the wave length of optical beams.

Paragraph beginning at line 7 of page 8 has been amended as follows:

> In the method for adjusting the optical properties of a dielectric ARC layer, the dielectric anti-reflective coating layer is deposited of a material selected from the group consisting of SiO_2, SiON and SiONH. The method may further include the step

of annealing the dielectric ARC layer at a temperature between about 400°C and about 1,000°C. The method may further include the step of annealing the dielectric ARC layer for a timer period between about 1 min. and about 30 min., preferably between about 3 min. and about 5 min. The method may further include the step of adjusting the optical properties of the dielectric ARC layer to a [reflective] refractive index (n) between about 2.0 and about 2.5, and an extinction coefficient (k) between about 0.2 and about 0.8.

Paragraph beginning at line 19 of page 9 has been amended as follows:

Figure 1 is a graph illustrating changes in the [reflective] refractive index based on changes in the SiH_4/N_2O mix ratio for a dielectric ARC layer of SiON.

Paragraph beginning at line 4 of page 10 has been amended as follows:

Figure 3 is a graph illustrating a relationship between the

[reflective] refractive index and the extinction coefficient for a dielectric ARC of SiON.

Paragraph beginning at line 8 of page 10 has been amended as follows:

Figure 4 is a graph illustrating the effect of annealing on the [reflective] refractive index n and the extinction coefficient k at various annealing temperatures between 300°C and 900°C.

Paragraph beginning at line 10 of page 10 has been amended as follows:

Figure 5 is a graph illustrating the relationship between the [reflective] refractive index n and the extinction coefficient k as deposited and after annealing in O_2 for a dielectric ARC of SiON.

Paragraph beginning at line 14 of page 10 has been amended as follows:

The present invention discloses a method for adjusting the optical properties of an anti-reflective coating layer or a dielectric ARC layer. The present invention method is particularly suited for adjusting the extinction coefficient, k, of a dielectric ARC layer while holding the [reflective] <u>refractive</u> index, n, at a constant value. The present invention novel method is particularly useful when a specific photolithographic process requires a different set of n and k values which requires changes to be made in one value but not in the other value. The conventional method of adjusting the values of the parameters is to change the plasma CVD recipe resulting in changes in both parameters. By utilizing the present invention novel method, the value of one parameter can be held constant while the value of the other parameter is being changed. For instance, the value of the reflective index n for a dielectric ARC layer of SiON can be held constant, while the extinction coefficient k of SiON can be reduced by a suitable annealing process. The present invention novel method enables the adjustment of a single optical parameter independently of the other optical parameter.

Paragraph beginning at line 1 of page 11 has been amended as follows:

of n and k values which requires changes to be made in one value but not in the other value. The conventional method of adjusting the values of the parameters is to change the plasma CVD recipe resulting in changes in both parameters. By utilizing the present invention novel method, the value of one parameter can be held constant while the value of the other parameter is being changed. For instance, the value of the [reflective] <u>refractive</u> index n for a dielectric ARC layer of SiON can be held constant, while the extinction coefficient k of SiON can be reduced by a suitable annealing process. The present invention novel method enables the adjustment of a single optical parameter independently of the other optical parameter.

Paragraph beginning at line 7 of page 15 has been amended as follows:

The beneficial effect of the present invention novel method is further illustrated in Figure 5, i.e. in a graph illustrating the inter-dependency of the extinction coefficient k on the

[reflective] refractive index n. It is seen that, while the as-deposited SiON layer shows a linear dependency between the two parameters, the annealed films show an entirely different result. After annealing in an oxygen environment for a time period of about 3 min., the reflective index value, n, remains substantially unchanged (fluctuating between a value of 2.16 and 2.18), while the value of the extinction coefficient, k, changes drastically from 0.70 to about 0.30. A film thickness for the SiON layer deposited by the plasma enhanced CVD method is about 620 Å. It should be noted that, for comparison purposes, n = 1.46 and k = 0 for a pure SiO_2 layer, while n = 2~2.1 and k = 0.3 for a pure Si_3N_4 layer.

In The Claims

Claim 1 has been amended as follows:

1. (Amended) A method for adjusting the optical properties of an anti-reflective coating (ARC) layer comprising the steps of:

providing a preprocessed semiconductor substrate having a SiN_x or a polysilicon layer on a top surface;

depositing a dielectric ARC layer on said SiN_x or said polysilicon layer; and

annealing said dielectric ARC layer deposited on said

semiconductor substrate at a temperature of at least [400] <u>500</u>°C and in a gas comprising at least one element selected from the group consisting of N_2 and O_2.

Claim 11 has been amended as follows:

11. (Amended) A method for adjusting the optical properties of an anti-reflective coating layer according to claim 1 further comprising the step of annealing said dielectric anti-reflective coating layer for a time period between about [1] <u>3</u> min. and about [30] <u>5</u> min.

Claim 13 has been amended as follows:

13. (Amended) A method for adjusting the extinction coefficient (k) of a dielectric anti-reflective coating layer by the steps of:

providing a SiN_x or polysilicon layer covered semiconductor substrate;

depositing a dielectric anti-reflective coating layer of a material selected from the group consisting of SiO_2, SiON and SiONH on top of said SiN_x or said polysilicon layer; and

heating said semiconductor substrate to a temperature between about [400] 500°C and about 1,000°C in an environment that comprises at least one of N_2 or O_2.

Claim 14 has been amended as follows:

14. (Amended) A method for adjusting the extinction coefficient (k) of a dielectric anti-reflective coating layer according to claim 13 further comprising the step of heating said semiconductor substrate for a length of time sufficient to vary the extinction coefficient of said dielectric anti-reflective [coting] coating layer by at least 10%.

Claim 17 has been amended as follows:

17. (Amended) A method for adjusting the extinction coefficient (k) of a dielectric anti-reflective coating layer according to claim 13 further comprising the step of heating said semiconductor substrate to a temperature [of at least 600] between 500°C and 700°C in an environment of O_2.

In The Abstract

A method for adjusting the optical properties of an anti-reflective coating layer by thermal annealing is described. In the method, a dielectric ARC layer of SiON is first deposited by plasma enhanced CVD to a thickness of at least 500 Å. The dielectric ARC layer is deposited on a silicon nitride layer or on a polysilicon layer which can withstand the annealing temperature used for the dielectric ARC layer. The dielectric ARC layer can be annealed at a temperature of at least 400°C, or in a temperature range between about 400°C and about 1,000°C. The annealing process can be conducted in a gas environment that contains at least one of N_2 and O_2. [A suitable annealing time is between about 1 min. and about 30 min., or preferably between about 3 min. and about 5 min. The annealing process has substantially no effect on the value of the reflective index, n, the present invention novel method allows adjustment in the extinction coefficient, k, to be made independently in the SiON dielectric ARC layer.]